

PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project New Fish tagging System	
BPA project number	8331900
Contract renewal date (mm/yyyy)	10/99
Multiple actions? (indicate Yes or No)	Yes
Business name of agency, institution or organization requesting funding National Marine Fisheries Service	
Business acronym (if appropriate)	NMFS
Proposal contact person or principal investigator:	
Name	Earl Prentice
Mailing address	2725 Montlake Blvd. East
City, ST Zip	Seattle, WA 98112
Phone	206-842-4289
Fax	206-842-8364
Email address	Earl.Prentice@noaa.gov
NPPC Program Measure Number(s) which this project addresses 5.OF.9,10,11,12,13	
FWS/NMFS Biological Opinion Number(s) which this project addresses ITS 14	
Other planning document references Recovery Plan (examples are 2.1D; 2.3.b.4; 2.4.a; 2.6.c.2; and 2.9.d). The capability of interrogating returning PIT-tagged adult salmonids at federal dams throughout the Columbia River Basin (CRB) is called for in 1995 Biological Opinion relating to the Federal Columbia River Power System (FCRPS). In the Biological Opinion it states that Bonneville Power Administration (BPA), U.S. Army Corps of Engineers (COE), and National Marine Fisheries Service (NMFS) will be responsible for implementing this capability within the CRB.	
Short description Determine the biological and technical feasibility of using PIT-tag technology to obtain information on juvenile and adult salmonids. Develop ancillary equipment to expand the PIT-tag system's capabilities to meet CRB resource stakeholder needs.	
Target species All salmonids	

Section 2. Sorting and evaluation

Subbasin Snake and Columbia River Basins
--

Evaluation Process Sort

CBFWA caucus		CBFWA eval. Process		ISRP project type	
X one or more caucus		If your project fits either of these processes, X one or both		X one or more categories	
x	Anadromous fish	x	Multi-year (milestone-based evaluation)		Watershed councils/model watersheds
x	Resident Fish		Watershed project eval.	x	Information dissemination
	Wildlife			x	Operation & maintenance
				x	New construction
				x	Research & monitoring
				x	Implementation & mgmt
					Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
8712700	Smolt Monitoring by Non-federal agencies	System development and evaluation
9008000	Columbia Basin PIT-tag Information System	System development, evaluation, and technical assistance
9701000	PIT-tag System Transition	Technical assistance and evaluation of systems
	All projects that use PIT tags and PIT-tag information	Technical assistance

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1984-85	Developed tagging techniques for PIT tags	Yes
1984-86	Developed tagging equipment	Yes
1986-87	Developed automatic data entry station for tagging fish	Yes
1986-88	Investigated the effects of PIT tags on juvenile salmonids and determining tag retention	Yes
1986	Installed first prototype PIT-tag interrogation system at McNary Dam	Yes
1987-98	Designed and installed juvenile salmon PIT-tag interrogation systems at CRB dams	Yes
1987	Installed first PIT-tag interrogation system for adult salmon at Lower Granite Dam	Yes
1987	Developed prototype PIT-tag database for the CRB	Yes
1988	Developed slide-gate fish diversion system	Yes
1989-96	Evaluated effects of electromagnetic fields on juvenile and adult salmon (reproduction and behavior)	Yes
1990-92	Evaluated the technical feasibility of an acoustic PIT tag	Yes
1990-96	Investigated the effects of PIT tags on growth, behavior, and survival for different salmonid species	Yes
1993-95	Compared overwinter survival of hatchery coho released to wild in comparison to CWT	Yes
1994	Completed predator avoidance testing PIT-tag vs other tags	Yes
1995	Initiated a long-term tag retention study	No (test fish eaten)
1995	Installed and evaluated Separation-by-Code system (computer program and 2 and 3-way rotational fish diversion gates) at Lower Granite Dam	Yes
1996-98	Participated in the evaluation of 134-kHz ISO-based transceivers	Yes
1996	Developed and installed the first 400-kHz flat-plate interrogation system	Yes
1996	Installed Separation-by-Code system at	Yes

	Little Goose Dam.	
1996	Developed first underwater PIT-tag interrogation system	Yes
1997	Installed the computer program MULTIMON into the main CRB sites	Yes
1998	Installed PIT-tag interrogation system in Bonneville Dam's adult monitoring facility	Yes
1998	Evaluated PIT-tag interrogation systems at Bonneville Dam for tag-reading efficiency	Yes
1998	Completed development of a 3-way side-to-side fish diverter	Yes
1998	Directed fish tests for ISO-based PIT-tag system for juvenile salmon and made recommendations to proceed with transition	Yes
1998	Designed antenna systems for interrogation of adult salmon in fish ladders (orifices). Conducted basic development work on companion transceiver systems.	Yes

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Develop an extended-range PIT-tag interrogation system for adult salmon and other fish	a	Make refinements to interrogation systems for orifices evaluated in FY99
		b	Install and evaluate an interrogation system covering orifices for one fish ladder at Bonneville Dam.
		c	Continue development of 134.2-kHz ISO-based pass-by PIT-tag interrogation systems for detecting adult fish in ladders
2	Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam	a	Fabricate the 134.2-kHz flat-plate system for Bonneville Dam.
		b	Install and evaluate the flat-plate system
		c	Maintain the flat plate system and Make modifications as required to meet performance specifications
3	Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon	a	Conduct tests, evaluate equipment and tags, and participate in planning and coordination meetings

Obj 1,2,3	Objective	Task a,b,c	Task
4	Information & technology transfer and assistance	a	Transfer technology developed by NMFS to PIT-tag users and assist users with PIT-tag technology

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measurable biological objective(s)	Milestone	FY2000 Cost %
1	10/1999	9/2000	Develop an extended-range PIT-tag interrogation system for adult salmon and other fish	Operational interrogation system covering the orifices in a fish ladder	43.99
2	10/1999	9/2000	Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam	Operational 134.2-kHz flat-plate interrogation system at Bonneville Dam	6.82
3	10/1999	9/2000	Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon	Functional 134.2-kHz ISO-base PIT-tag system for juvenile salmon at CRB dams	0.41
4	10/1999	9/2000	Information & technology transfer and assistance	Successful transfer of technology developed by NMFS and assistance to users of PIT-tag technology	0.22
				Total	51.44*

* Percentage does not include labor (total labor 48.56 % of the project) for each objective.

Schedule constraints

An inadequate budget would prevent developments, installations, and evaluations from proceeding in a timely and efficient manner and would prevent us from meeting Biological Opinion and other ESA obligations. Other factors that could create major problems include severe weather and delays in obtaining approvals and permits. These factors could prevent us from meeting schedule driven windows for equipment installation (e.g., ladder dewatering). Technical problems at any time could alter our proposed activities and their schedules.

Completion date

2007

Section 5. Budget

FY99 project budget (BPA obligated):	\$1,173,500
---	--------------------

FY2000 budget by line item

Item	Note	% of total	FY2000 (\$)
Personnel		27.86	385900
Fringe benefits		5.91	81800
Supplies, materials, non-expendable property		21.70	300600
Operations & maintenance		2.70	37400
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	NA	NA	NA
NEPA costs	NA	NA	NA
Construction-related support	NA		
PIT tags	1,300	0.30	3800
Travel		3.43	47500
Indirect costs		12.35	171000
Subcontractor		26.00	360100
Other		0.01	700
TOTAL BPA REQUESTED BUDGET			1388800

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount (\$)
NA			
Total project cost (including BPA portion)			

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	1,450,000	1,400,000	1,300,000	1,100,000

Section 6. References

Watershed?	Reference
NA	

PART II - NARRATIVE

Section 7. Abstract

Resource managers rely upon the data produced by studies using PIT tags to make critical decisions that are necessary to the Biological Opinion for Operation of the Federal Columbia River Power System, the proposed Snake River Recovery Plan, and other Regional plans. Currently, these data are mostly collected on juvenile salmon with some data collected at Lower Granite and Bonneville Dams on returning adult salmon. In order to evaluate the success of various restoration strategies, it will be critical to collect data on migrating adult salmon through mainstem Columbia River dams. Thus, NMFS is developing interrogation systems for adult salmon. The initial work is concentrating on detection in fish ladder orifices. This main objective and the other objectives for the project are outlined below and discussed fully in the Section 8.

The proposed work has four main objectives: I) Develop an extended-range PIT-tag interrogation system for adult salmon and other fish; II) Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam, III) Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon, and IV) Information & technology transfer and assistance. For each of the project objectives and tasks, realistic milestones have been established.

In FY00, Cascades Island fish ladder will have the orifices of up to four weirs equipped with PIT-tag interrogation equipment. Tag-reading efficiency will be determined using a combination of PIT-tagged fish, video, and radio tags. If Objective I is completed without technical difficulty in FY00, the plan is to proceed with installation of PIT-tag interrogation equipment in all ladders of Bonneville Dam in FY01. In subsequent years, similar systems would be installed at other dams in the CRB.

The 134.2-kHz flat-plate PIT-tag system for Bonneville Dam developed in FY99 should be fully functional for the 2000 outmigration (Objective II). The installed system will provide continued PIT-tag interrogation coverage after the transition to the 134.2-kHz PIT-tag system in the CRB. This objective should be completed in FY00.

Assistance to BPA on the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon (Objective III) should be completed at the conclusion of FY00.

NMFS transfers information and technology (Objective IV) to the fishery agencies as the developed technology is completed and deemed ready for use in the CRB. Thus, Objective IV will continue past FY00.

Section 8. Project description

a. Technical and/or scientific background

General Introduction

Bonneville Power Administration (BPA) initiated a contract with National Marine Fisheries Service (NMFS) in 1983 to determine the technical and biological feasibility of applying Passive Integrated Transponder (PIT) tag and associated technology to fishery problems in the Columbia River Basin (CRB). NMFS designed, evaluated, and implemented such a system using a 400-kHz frequency PIT tag. The PIT-tag system in conjunction with ancillary equipment enables data to be passively collected on individual juvenile and adult salmonids at a network of sites throughout the CRB in near real time without the fish being handled.

Resource managers rely upon the data produced by studies using PIT tags (e.g., Survival Estimates for the Passage of Juvenile Salmonids Through Snake and Columbia River Dams and Reservoirs) to make critical decisions that are necessary to the Biological Opinion for Operation of the Federal Columbia River Power System, the proposed Snake River Recovery Plan, and other Regional plans. Currently, these data are mostly collected on juvenile salmon with some data collected at Lower Granite and Bonneville Dams on returning adult salmon. In order to evaluate the success of various restoration strategies, it will be critical to collect data on migrating adult salmon through mainstem Columbia River dams. Thus, NMFS is developing interrogation systems for adult salmon. The initial work is concentrating on detection in fish ladder orifices.

NMFS proposes the following PIT-tag system research and development work for the period of 1 October 1999 through 30 September 2000 (FY00). The proposed work consists of four main objectives: I) Develop an extended-range PIT-tag interrogation system for adult salmon and other fish; II) Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam; III) Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon; and IV) Information & technology transfer and assistance.

Below are individual introductions for each of these objectives.

Objective I: Develop an extended-range PIT-tag interrogation system for adult salmon and other fish

Introduction

The need for detection of returning adult salmon has long been known. However, detection of PIT-tagged adult fish has only been possible on a small scale due to limitations of the current 400-kHz PIT-tag technology used in the CRB. Currently, adult salmon are only being interrogated in 31-cm pipes at Lower Granite and Bonneville Dams (only at the adult monitoring facility).

The current network of 400-kHz PIT-tag interrogation systems for juvenile salmon will be replaced with the 134.2-kHz ISO-based system in time for the outmigration of juvenile salmon in 2000. Longer read range is possible with the 134.2-kHz tags than the 400-kHz tags, because they incorporate a different data recovery scheme, new silicon technology, and are governed by less stringent Federal Communication Commission (FCC) emission regulations. These advantages should enable the detection of returning adult salmon at several locations associated with fish ladders instead of being restricted to small diameter pipes as with the 400-kHz technology. NMFS is taking advantage of the enhanced performance of the ISO-based system and is working toward the goal of interrogating PIT-tagged fish in a variety of locations in fish ladders. The initial work is concentrating on detection in fish ladder orifices. Then based on the flat-plate system developed for Bonneville Dam, pass-by technology will be investigated for detecting fish going through vertical slots and using the overfall portions of the weirs.

Objective II: Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam

Introduction

In the year 2000, the main CRB sites will be equipped with the new ISO-based stationary transceivers. Thus, only those juvenile salmon tagged with the new 134.2-kHz PIT tags will be monitored. A 400-kHz flat-plate (pass-by) PIT-tag interrogation system is currently installed at Bonneville Dam's First Powerhouse. This system will need to be replaced with a 134.2-kHz system for the year 2000 field season to meet the informational needs of fisheries investigators and managers in the CRB. Working towards this end, NMFS has been working on a 134.2-kHz ISO-based flat-plate interrogation system to replace the current system (FY99 work element).

Objective III: Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon

Introduction

To provide for a smooth transition from the 400-kHz technology to the ISO-based technology and to ensure that CRB salmon research is not adversely affected, BPA in 1997 established the "Transition Planning Team" to oversee the entire transition, the "Transceiver Technical Evaluation

Team" to oversee the development of the stationary transceiver, the "Portable Technical Evaluation Team" to oversee the development of the portable transceiver, and the "Tag Development Team" to oversee the development of suitable PIT tags. It also established an "Infrastructure Team" to oversee any construction necessary at the dams for the transition, the installation of the 134.2-kHz stationary transceivers, and the necessary changes to the tagging software and PTAGIS database for implementing the 134.2-kHz system. During FY99, the duties of the Transceiver Technical Evaluation Team, Portable Technical Evaluation Team, and Infrastructure Team will be completed and the teams terminated. However, because of the importance of PIT tags to CRB research, NMFS personnel from these teams will be available during the first season to assist BPA in solving any problems that surface with the new PIT-tag equipment. In addition, NMFS has been requested by BPA to continue to provide representatives on the Transition Planning Team and the Tag Development Team.

Objective IV: Information & technology transfer and assistance

Introduction

We propose that NMFS continue its activity of interfacing with other agencies regarding PIT-tag related matters (e.g., facility design to accommodate PIT-tag systems, system maintenance, system design specifications, assistance in using prototype equipment and MULTIMON computer program, information transfer, etc.). Since NMFS personnel designed or helped develop many of the present PIT-tag system components within the CRB, they are an important resource for providing technical support and training to ensure the reliable operation of PIT-tag technology throughout the CRB.

b. Rationale and significance to Regional Programs

As shown by our research and development efforts to date (see Section 8.d), this project has and will continue to result in products that aid stakeholders in assessing the effectiveness of various actions taken to enhance the survival of juvenile and adult salmonids. Specifically, the research and development effort will provide: 1) approaches that will enable fishery researchers and managers to address previously unanswered questions; 2) accurate and reliable data in near real time that enable effective decisions to be made regarding multiple species in a variety of habitats; 3) products that can be used in genetic, physiology, behavior, and broodstock research efforts on endangered species; and 4) products that can be used in obtaining survival and migration timing information on stocks for evaluating water management strategies at fish passage/collection facilities.

The products resulting from this research and development effort are being used in genetic, physiology, behavior, and broodstock research efforts as related to endangered species. The continued development of the PIT-tag and ancillary equipment will further expand the system's capabilities by enabling issues to be addressed that are expressed in both the Biological Opinion for operation of the Federal Columbia River Power System and the proposed Snake River Recovery Plan (Tasks 2.1D, 2.3.b.4, 2.4.a, 2.6.c.2, and 2.9.d).

All ongoing and proposed research in the CRB using PIT-tag technology is the result of NMFS's continuing PIT-tag research and development effort. Many of these projects are dependent upon the development of extended-range PIT-tag interrogation systems (i.e., adult interrogation) in the near future. NMFS will focus much of its effort on this requirement. However, we will also continue to propose new and innovative approaches to interrogate juvenile and adult fish.

c. Relationships to other projects

Virtually all projects that rely on PIT-tag information are dependent on the continued support of this project. Research and development efforts within this project have and will continue to result in products that aid stakeholders in evaluating the success of various restoration strategies to enhance the survival of juvenile and adult salmonids. The products provide approaches that enable fisheries researchers and managers to address previously unanswered questions. In addition, they provide accurate and reliable data in near real time that enables effective management of multiple species in a variety of habitats. The products are used in genetic, physiology, behavior, and broodstock research efforts on endangered species. This research is also used in obtaining survival and migration timing information on stocks for evaluating water management strategies at fish passage/collection facilities. This research aids all stakeholders by providing data needed for the management and restoration of salmonids and other fish.

To continue providing technology that can meet the needs of the fisheries community, ample lead time for the development and evaluation of such technology is required. In many instances, specific applications for a product cannot be cited at the time of its development, but a general need can be described. An example is the development of the Separation-by-Code system that enables the control of fish separation based on specific tag codes. When this development effort was initiated, PIT-tag users were not calling for this capability; yet, now that the product is available, many PIT-tag users need the Separation-by-Code system to carry out their research. Examples of projects include, BPA-sponsored "Survival Estimation for Dam/Reservoir Passage", COE-sponsored Transportation studies, and the COE-sponsored The Dalles Dam Spill study.

d. Project history (for ongoing projects)

The biological studies associated with the PIT-tag project have been conducted in the laboratory, in the field under controlled conditions, and in the field under natural conditions. The results of these studies are available in reports and journals (see publications list).

In the laboratory, we have been able to determine: 1) a suitable anatomical area and insertion techniques for PIT-tag placement within salmonids that are acceptable from biological and human standpoints; 2) the minimum sized juvenile salmonid that can be effectively tagged with a PIT tag; 3) host tissue response to the tag; 4) the effects of tags on growth and survival for various salmonid species; 5) tag wound healing rate and disease occurrence from tagging; 6) tag effects on swimming performance of parr, transitional, and smolted salmon; 7) effect of electromagnetic

fields on the biology of salmon and a surrogate fish species, medaka; 8) predator avoidance of tagged fish; and 9) PIT-tag retention in various sizes and species of salmonids in relation to traditional tags and marks.

Under controlled field conditions we have determined: 1) susceptibility of PIT-tagged and traditionally marked and tagged fish to predators in both clear and turbid water; 2) the growth, survival, and tag retention of several species of salmonids held for extended periods in both fresh water and sea water; and 3) the behavior of PIT-tagged juvenile salmonids to various geometries and colors of PIT-tag interrogation passageways.

Under natural conditions in the field we have determined: 1) return rate, tag retention, size at return, and timing of PIT-tagged coho salmon released to the wild; 2) overwinter survival (recapture rate) of coho salmon released to the wild compared to coded wire tagged and other traditional tagged and marked fish; 3) the reaction of naturally migrating coho salmon to electromagnetic fields produced by an underwater PIT-tag interrogation system; and 4) the behavior of fish ascending a fish ladder using video equipment.

Products that have been developed by this project include: 1) PIT-tag injectors, both hand-held and semi-automatic; 2) a computer-based data entry station used while tagging fish; 3) the first rectangular pass-through, round pass-through, and pass-by PIT-tag interrogation systems for juvenile salmonids; 4) the first computer program for recording PIT-tagged fish passing through interrogation units at dams; 5) the first PIT-tag interrogation units for adult salmon; 6) the first CRB PIT-tag database; 7) rectangular slide gates; 8) two- and three- way fish diversion gates; 9) the first underwater PIT-tag interrogation unit; and 10) a multi-tasking computer program for controlling fish separation, subsampling, and data collection.

The above accomplishments are discussed in reports and journals (see publications list).

Project length 16 years

Total cost to date \$12,417,686.07

Average cost/ year \$776,105.28

PUBLICATIONS

Brannas, E., H. Lundqvist, E. Prentice, M. Schmitz, k. Brannas, and B. Wiklund.

1994. Use of the passive integrated transponder (PIT) in a fish identification and monitoring system for fish behavior studies. Trans. of the Am. Fish. Soc. 123:395-401.

Maynard, D. J., D. A. Frost, F. W. Waknitz, and E. F. Prentice.

1996. The vulnerability of marked age-0 steelhead to a visual predator. Trans. Am. Fish. Soc. 125:330-333.

- McCutcheon, C. S., E. F. Prentice, and D.L. Park.
1994. Passive monitoring of migrating adult steelhead with PIT tags. N. Am. J. of Fish. Man. 14:220-223.
- Nunnallee, E. P, E. F. Prentice, B. Jonasson, and W. Patten.
1998. Evaluation of a flat-plate PIT tg interrogation system at Bonneville Dam. J. Aquaculture Engineering. 17:261-272.
- Peterson, N. P., E. F. Prentice, and T. P. Quinn.
1994. Comparison of Sequential coded wire and passive integrated transponder tags for assessing overwinter growth and survival of juvenile coho salmon. N. Am. J. of Fish. Man. 14:870-873.
- Prentice, E. F.
1987. A passive integrated transponder tag for fish and crustaceans. Proceedings of Scan-Tech 87, Session 2B/4C. Kansas City, Kansas. p. 8-34.
- Prentice, E. F.
1990. A new internal telemetry tag for fish and crustaceans. NOAA Technical Report NMFS 85. Proceedings Fifteenth U.S.-Japan Meetings on Aquaculture. Albert Sparks (editor). p9.
- Prentice, E. F., T. A. Flagg, and C. McCutcheon.
1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. Am. Fish. Soc. Symp. 7:317-322.
- Prentice, E. F., T. A. Flagg, C. McCutcheon, and D. Brastow.
1990. PIT-tag monitoring systems for hydroelectric dams and fish hatcheries. Am. Fish. Soc. Symp. 7:323-334.
- Prentice, E. F., T. A. Flagg, C. McCutcheon, D. Brastow, and D. Cross.
1990. Equipment, methods, and an automated data-entry station for PIT tagging. Am. Fish. Soc. Symp. 7:335-340.
- Prentice, E. F., and D. E. Schneider.
1979. Respiration and thermal tolerance of the Dungeness crab, Cancer magister dana. Comp. Biochem. Physiol. 63(A):591-597.

PROCESSED REPORTS

- Prentice, E. F., and D. L. Park.
1984. A study to determine the biological feasibility of a new fish tagging system. U.S. Dep. of Commer., NOAA, NMFS, Northwest and Alaska Fish. Cent., Seattle, Wash. 38 p. plus Appendix. (Report to Bonneville Power Administration, Contract DE-A179-83BP11982).

Prentice, E. F., C. W. Sims, and D. L. Park.

1985. A study to determine the biological feasibility of a new fish tagging system. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest and Alaska Fish. Cent., Seattle, WA. 34 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., D. L. Park, T. A. Flagg, and C. S. McCutcheon.

1986. A study to determine the biological feasibility of a new fish tagging system. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest and Alaska Fish. Cent., Seattle, WA. 79 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon.

1987. A study to determine the biological feasibility of a new fish tagging system. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest and Alaska Fish. Cent., Seattle, WA. 109 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., D. Maynard, P. Sparks-McConkey, C. S. McCutcheon, D. Neff, W. Steffinns, F. W. Waknitz, A. L. Jensen, L. C. Stuehrenberg, S.L. Downing, B. Standford, and T. W. Newcomb.

1993. A study to determine the biological feasibility of a new fish tagging system. Annual Report 1983. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. 131 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., D. Maynard, S. L. Downing, D. A. Frost, M. S. Kellett, D. A. Bruland, P. Sparks-McConkey, F. W. Waknitz, R. N. Iwamoto, K. McIntyre, and N. Paasch.

1994. A study to determine the biological feasibility of a new fish tagging system. Annual Report 1990-93. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. 209 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., S. L. Downing, E. P. Nunnallee, B. W. Peterson, and B. F. Jonasson.

In press. Development of an Extended-range PIT-tag Interrogation. Annual Report 1995-96. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. x p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., S. L. Downing, and E. P. Nunnallee.

In press. Evaluation of potential passive acoustic tag systems. Annual Report 1994-96. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. x p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

e. **Proposal objectives.**

Measurable Objectives and Deliverables by Work Element

Work Element I: Develop an extended-range PIT-tag interrogation system for adult salmon and other fish

Task A: Make refinements to interrogation systems for orifices evaluated in FY99

Objectives:

- 1) Make modifications to digital controller for use with transceiver systems.
- 2) Modify antenna housing designs and geometries as required.
- 3) Design RF shields for electromagnetic noise suppression as needed to meet FCC/NTIA emissions limits.
- 4) If impractical to shield, apply for an FCC site license to exceed the permissible emissions levels.

Deliverables:

- 1) Interrogation units ready for installation into multiple orifices
(December 1999)
- 2) Summary report covering FY00 activities
(January 2001)

Task B: Install and evaluate an interrogation system covering orifices for one fish ladder at Bonneville Dam

Objectives:

- 1) Prepare concept drawings for presentation at meetings.
- 2) Meet with resource stakeholders to determine site preference, needs, concerns and objections.
- 3) Obtain preliminary approval for system installation at a specified site.
- 4) Prepare technical drawings for final approval and cost estimation.
- 5) Review and submit drawings for final approval.

- 6) Prepare and submit documents to obtain ESA and other required permits.
- 7) Establish contracts for equipment installation and video documentation of fish behavior.
- 8) Install a PIT-tag interrogation system that covers orifices in a maximum of four weirs in the Cascades Island fish ladder at Bonneville Dam.
- 9) Conduct electronic tests on the interrogation system to determine functionality and performance limitations.
- 10) Determine tag-reading efficiency using tagged neutrally buoyant fish surrogates and fish, and a suite of tools (i.e., PIT-tags, radio tags, Peterson disk tags, and video).

Deliverables:

- 1) Technical drawings for final approval and cost estimation (October 1999)
- 2) Permits for installation and evaluation of the system (November 1999)
- 3) Installed system at Cascades Island fish ladder (March 2000)
- 4) Completed evaluation of system (September 2000)
- 5) Summary report covering FY00 activities (January 2001)

Task C: Continue development of 134.2-kHz pass-by PIT-tag interrogation systems for adult fish in ladders

Objectives:

- 1) Evaluate pass-by system developed for Bonneville Dam for its ability to operate in the overfall portion of a weir and in a vertical slot.
- 2) Determine the best methods for increasing read distance for pass-by systems.
- 3) Begin development of an engineering design model for the horizontal and vertical array pass-by antenna system for vertical fish ladder slots.

- 4) Develop antenna/transceiver multiplexing capabilities for the pass-by systems as needed to reduce interference between antennas and/or for FCC compliance.
- 5) Prepare concept drawings for presentation at meetings.

Deliverables:

- 1) Report on preliminary findings on tests done on various pass-by antenna designs (March 2000)
- 2) Concept drawings (September 2000)
- 3) Summary report covering FY00 activities (January 2001)

Work Element II: Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam

Task A: Fabricate the approved final design for the 134.2-kHz flat-plate system for Bonneville Dam

Objectives:

- 1) Fabricate the final design for the antenna and transceiver components.

Deliverables:

- 1) Antennas and transceivers ready for installation (December 1999)
- 2) Summary report of FY00 activities (January 2001)

Task B: Install and evaluate the flat-plate system

Objectives:

- 1) Install the flat-plate interrogation system at Bonneville Dam.
- 2) Conduct electronic tests.
- 3) Conduct tag-reading efficiency tests using PIT-tagged sticks and fish.

Deliverables:

- 1) Installed 134.2-kHz flat-plate interrogation system
(January 2000)
- 2) Completed electronic tests
(September 2000)
- 3) Completed tag-reading efficiency tests
(September 2000)
- 4) Summary report of FY00 activities
(January 2001)

Task C: Maintain the flat-plate system and make modifications as required to meet performance specifications**Objectives:**

- 1) Maintain the flat-plate system and make any necessary modifications.

Deliverables:

- 1) Summary report of FY00 activities
(January 2001)

Work Element III: Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon**Objectives:**

- 1) Participate in team meetings.
- 2) Assist in any troubleshooting of the new ISO-based system necessary to ensure that CRB research proceeds smoothly.

Deliverables:

- 1) Summary report of FY00 activities
(January 2001)

Work Element IV: Information & technology transfer and assistance

Objectives:

- 1) Transfer information and technology to PIT-tag users.
- 2) Assist PIT-tag technology users.

Deliverables:

- 1) Summary report of FY00 activities
(January 2001)

f. Methods

Work Element I: Develop an extended-range PIT-tag interrogation system for adult salmon and other fish

Proposed work

Task A: Make refinements to interrogation systems for orifices evaluated in FY99

The technology to interrogate adult salmon going through different interrogation sites (initial work will concentrate on detection in orifices) at dams is being developed by NMFS and will be evaluated over time. In FY99, several antenna geometries and transceiver systems will be evaluated in orifices at Bonneville Dam. The best system(s) will be further refined in FY00 (Task I). Refinements may include modifications to digital controllers for use with specific transceiver systems; modifications to antenna housing designs and geometries; designing RF shields for electromagnetic noise suppression; and applying for a FCC site license. At this time it is not possible to anticipate all of the modifications because the FY99 field work has not been completed.

Task B: Install and evaluate an interrogation system covering orifices for one fish ladder at Bonneville Dam

We propose that the system resulting from Task I be installed in the orifices of four weirs at Cascades Island fish ladder for further evaluation in FY00. Technical drawings would be obtained and made available for review and approval. Permits to install and test fish would be obtained. The system would then be installed during the scheduled maintenance-dewatering period. The electronics of the installed system will be evaluated throughout the field season. In addition, fish behavior through the orifices with installed interrogation systems will be video taped and compared to unmodified control orifices. Tag-reading efficiency will be determined using a combination of PIT-tagged, radio-tagged, and Peterson disk-tagged fish in addition to video. Since the overfalls will not have PIT-tag interrogation units, the aforementioned tools will be used

to verify the route each PIT-tagged fish took in order to determine the actual number of PIT-tagged fish using particular orifices. If the system is found to be satisfactory, we propose to expand interrogation to all of the fish ladders at Bonneville Dam in FY01 (the number of orifices or sites covered will be determined with input from the fisheries community).

Task C: Continue development of 134.2-kHz pass-by PIT-tag interrogation systems for adult fish in ladders

Task C focuses on the need to evaluate 100% of the fish at a ladder rather than just the approximately 90% that are covered with the orifice-only approach. This will mean that fish would need to be interrogated at the overfall portion of the weirs and in vertical slots. Capitalizing on the 134.2-kHz pass-by system developed for Bonneville Dam, we propose to continue development of the pass-by systems technology and apply it to these ladder locations.

The first step would be to evaluate how the system developed for Bonneville Dam would perform under the conditions present at these locations. We already know that read distance is going to be a problem even in the narrowest vertical slots (60 cm). Therefore, we will be examining methods for increasing read distance for pass-by systems. For example, we might investigate power amplification in conjunction with noise filtering. Once a pass-by system is developed, we would build an engineering design model. In addition, we will have concept drawings produced for presenting the system to the fisheries community and the COE.

Work Element II: Fabricate, install, and evaluate the 134.2-kHz flat-plate interrogation system for Bonneville Dam

Proposed work

Task A: Fabricate the approved final design for the 134.2-kHz flat-plate system for Bonneville Dam

Based on the best system design determined in FY99, the components for the 134.2-kHz ISO-base flat-plate system will be fabricated at the beginning of FY00.

Task B: Install and evaluate a 134.2-kHz flat-plate system

The flat-plate system will be installed in January 2000. Electronic tests will be performed to insure proper system operation. Tag-reading efficiency tests will be conducted using PIT-tagged sticks and fish. Two hundred juvenile hatchery salmonids will be PIT-tagged and released into the downstream migrant channel. The number of fish released will be compared to the number of tags read (tag reading efficiency). This test is identical to those conducted in the past with the 400-kHz system.

Task C: Maintain the flat-plate system and make modifications as required to meet performance specifications

During the field season, the newly installed system will be monitored by reviewing the daily files sent automatically to PTAGIS and via conversations with NMFS fish monitoring personnel located at the facility. These same personnel will also conduct daily stick tests to determine how well the the system performs over time. NMFS proposes to conduct system maintenance during the field season on an as-needed basis to insure system reliability. Furthermore, if system improvements are required from either performance or reliability standpoints, NMFS will make such changes.

Work Element III: Assist BPA in the basin-wide transition to the 134.2-kHz ISO-based PIT-tag system for juvenile salmon

Proposed Work

Transition Planning Team

This multiple agency team meets every 2-3 months in order to discuss the progress of the various technical teams, make decisions on schedules, to review results, and to direct transition related work. Our representatives will continue to participate in these meetings during FY00. NMFS personnel will also continue to participate on the Transceiver Technical Evaluation Team if the team is continued in FY00. However, at this time it is anticipated that once the stationary transceivers are installed and performance satisfactory, this team will be eliminated. NMFS personnel will aid in evaluating the system and if the performance is unsatisfactory, they will help to troubleshoot the system to ensure that CRB research is not negatively impacted. Otherwise, the routine monitoring of the new transceivers will be performed by Pacific States Marine Fisheries Commission. Changes to the system for FY01 will be recommended by the Transition Planning Team based on the monitoring results.

Tag Development Team

NMFS personnel will continue to participate on the Tag Development Team (TDT). The 1997 fish tests at McNary Dam indicated that the 12-mm tags did not perform as well as the 13.5-mm tags. A non-fish read-range test appeared to accurately distinguish high quality 13.5-mm tags from lower quality 13.5-mm tags. In other words, during the fish test the previously identified high quality tags were read on more coils and fewer were missed entirely than the lower quality tags. However, the test did not appear to work with the Destron Fearing (DF) 12-mm tags. The goal of the TDT in FY00 will be to continue to develop a series of standardized tests that will accurately predict the performance of 12-mm tags. The TDT is also responsible for coordinating the development of performance criteria for 12-mm tags to be used with the new ISO-based interrogation system. This effort will continue during FY00.

The Tag Development Team also proposes to evaluate a 134.2-kHz tag that contains a shorter message (64 bits) compared to the ISO-defined 128-bit message during FY00. To evaluate this

shorter message properly, it will be necessary for DF to adapt their firmware to recognize these tags. This shorter message tag will be evaluated only at Manchester unless test results indicate tests should be performed at a dam. Any decision regarding basin-wide use of a non-ISO tag with the new ISO-based system will require regional consensus.

Work Element IV: Information & technology transfer and assistance

Proposed Work

NMFS proposes to continue providing assistance regarding PIT-tag interrogation systems and ancillary equipment to PSMFC, COE, BPA, and other agencies on an as-needed basis.

Technical reports and scientific papers are important means of transferring information and technology. During the performance period, NMFS proposes to complete a report describing the results of several years of PIT-tag development and evaluation work and a paper describing the different fish diversion gates that NMFS has developed.

g. Facilities and equipment

Most of the electronics for the described systems will be developed and evaluated at NMFS facilities located in Seattle, Manchester, and Pasco, Washington. NMFS Electronics Shop located at Sand Point is equipped with state-of-the-art electronics diagnostic and test equipment. The shop also has the capability of producing its own printed circuit boards for prototype systems. The shop has ample room for system development and bench test evaluation work. Being located in Seattle, most required electronics supplies are easily obtainable. This shop has been the prime site for the development of not only the electronic systems associated with the PIT-tag project, but also for radio-tag equipment and other electronics used by NMFS in the CRB.

The NMFS Design and Fabrication Shop is located at its Pasco Research Station. This shop has milling machines, sheet metal benders, welders, etc. and is capable of producing a variety of prototype equipment that may be required for this or any other NMFS project. The shop provides primary design and mechanical support to biologists working in the CRB. For example, the shop has in the past designed and constructed traveling screens used at turbine intakes, wet separators, fish collection equipment, most of the PIT-tag interrogation antenna housings, RF shields, and fish diversion gates. Shop personnel have also been instrumental in the installation of all equipment designed and fabricated.

After development, PIT-tag equipment is often evaluated at the test facility located at NMFS Manchester Research Station before it is evaluated at river sites. This facility includes both indoor and outdoor testing areas. The indoor laboratory measures 7.5-m wide by 15-m long. The laboratory has electronic test equipment and a large test platform that consists of a belt drive controlled by a PLC. This piece of equipment is used to evaluate transceiver systems and antenna designs. The outdoor test area is configured to emulate a portion of a juvenile fish collection facility. Water velocity and volume can be controlled and directed to flow down pipes and flumes

to which PIT-tag interrogation and ancillary equipment can be installed for evaluation. Among other uses, the test facility has been used to evaluate the ISO-based stationary and portable transceiver systems being considered for the CRB.

Existing support equipment for both laboratory and field work are adequate to carry out the tasks outlined.

h. Budget

The attached FY00 budget reflects a decrease in the amount estimated at the time our FY99 proposal was submitted for consideration (mostly because we are not constructing the test barge).

However, the FY00 budget is higher than the current FY99 budget because of the high costs associated with two work elements. First, we are proposing to install a PIT-tag interrogation system to cover the entire Cascades Island adult fish ladder at Bonneville Dam (orifices in four weirs). This effort will require that multiple transceivers, antennas, etc. be purchased. In addition, the system will need to be installed over a very short time period and the subsequent evaluation will require a suite of tools and the services of multiple personnel. The other work element is the fabrication, installation, and evaluation of the 134.2-kHz flat-plate interrogation system for Bonneville Dam. This effort also requires the purchase of multiple transceivers, antennas, etc.

If adult PIT-tag interrogation is to become a reality and if continued interrogation of PIT-tagged juvenile salmonids at Bonneville Dam's First Powerhouse is needed, then the above work should be supported.

Section 9. Key personnel

Resume of: EARL F. PRENTICE

Education: 1962 - A.A., Skagit Valley Junior College - Major: Biology
1965 - B.A., Western Washington University- Major: Biology
1971 - M.S., Western Washington University- Major: Biology

Work Experience:
Job title: Task Manager, Fisheries Research Biologist, Supervisor
From: 1972 to Present
Employer information: National Marine Fisheries Service,
P.O. Box 130, Manchester, WA 98353
Supervisor: Douglas Dey (206) 860-3237

Expertise:
Since 1972 Mr. Prentice has been assigned to the NMFS Manchester Research Station. He has been a task manager for the Fish Ecology Division (formerly the Coastal Zone and Estuarine Studies Division) of the NMFS for 20 years.

Starting in 1983, he has been managing a project directed at developing PIT-tag technology and ancillary equipment for fisheries research. The project requires the services of personnel from a variety of disciplines within the general fields of biology, mechanical engineering, and electrical engineering. As project leader, he is responsible for: developing the research and system development work plans; developing and managing budgets; coordinating a number of individual research, development, and system installation work elements annually; developing the research plans for all the various work elements within the overall project; overseeing systems development, evaluation, and installation; coordinating the team's efforts with federal, state, tribal, and private resource stakeholders; and preparing reports and scientific research papers. In addition to his management responsibilities, he actively participates in the biological research projects and in the design and installation of the PIT-tag systems.

Job Completions:

- Determined host response to the PIT tag.
- Installed the first PIT-tag systems in the CRB.
- Initiated the development of a regional automated database to make PIT-tag information available to users in near real time.
- Directed the development of mechanical systems and a new computer program for the automatic separation of specific PIT-tagged fish from other fish based on the tag identification tag code.
- Directed the development of systems for PIT-tagging fish and automatically entering PIT-tag and related information into computer files.

Sample Publications

Nunnallee, E. P, E. F. Prentice, B. Jonasson, W. Patten.

1998. Evaluation of a flat-plate PIT tag interrogation system at Bonneville Dam. J. Aquaculture Engineering. 17:261-272.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon.

1987. A study to determine the biological feasibility of a new fish tagging system. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest and Alaska Fish. Cent., Seattle, WA. 109 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., D. Maynard, P. Sparks-McConkey, C. S. McCutcheon, D. Neff, W. Steffinns, F. W. Waknitz, A. L. Jensen, L. C. Stuehrenberg, S. L. Downing, B. Sandford, and T. W. Newcomb.

1993. A study to determine the biological feasibility of a new fish tagging system. Annual Report 1983. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. 131 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., D. Maynard, S. L. Downing, D. A. Frost, M. S. Kellett, D. A. Bruland, P. Sparks-McConkey, F. W. Waknitz, R. N. Iwamoto, K. McIntyre, and N. Paasch.

1994. A study to determine the biological feasibility of a new fish tagging system. Annual Report 1990-93. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. 209 p. plus Appendixes (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., S. L. Downing, E. P. Nunnallee, B. W. Peterson, and B. F. Jonasson.

In press. Development of an Extended-range PIT-tag Interrogation. Annual Report 1995-96. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Prentice, E. F., S. L. Downing, and E. P. Nunnallee.

In press. Evaluation of potential passive acoustic tag systems. Annual Report 1995-96. U.S. Dep. of Commer., Natl. Oceanic and Atmos. Admin., Natl. Marine Fish. Serv., Northwest Fish. Sci. Cent., Seattle, WA. (Report to Bonneville Power Administration, Contract DE-179-83BP11982, Project 83-19).

Resume of: BRADLEY W. PETERSON

Education: 1984 -- B.S. in Electrical Engineering. University of Kentucky

Work Experience:

Title: Group Leader, Electronic Engineering

Current Employer: National Marine Fisheries Service (NMFS)

Current Responsibilities: Oversee and participate in all PIT tag and radio tracking related electronic development, integration, and installations for NMFS.

Employment History:

1984 - 1989	U.S. Department of Defense Naval Electronic Systems Engineering Center 4297 Pacific Hwy. San Diego, CA 92110
1989- Present	U.S. Department of Commerce National Marine Fisheries Service Sand Point Way N.E., Bldg. #4 Seattle, WA 98115

Expertise:

Thirteen years of experience developing, modifying, purchasing, and installing microprocessor based signal acquisition systems for U.S. government. Seven years of experience designing, developing, modifying, and installing PIT-tag and radiotelemetry systems and equipment for fisheries research in the Columbia River Basin. Specific areas of expertise include microprocessor based systems design utilizing Zilog, Motorola, and Intel microprocessors that interface with existing or customized analog signal detection circuits. Assumed supervisory responsibility of the Electronic Engineering Group in 1993.

Job Completions:

- Development of dry (lab) test procedures and test equipment for BPA procurement of ISO-based 134.2-kHz PIT-tag stationary reader systems.
- Design and development of a high speed controller for 400-kHz PIT-tag diversion systems.
- Modification a 400-kHz juvenile PIT-tag detector for use in an underwater interrogation system.
- Design and development of a multichannel 30-MHz radio telemetry monitor for fisheries research.

Publications:

Hockersmith, E. E. and B. W. Peterson
1997. Use of Global Positioning System for Locating Radio-Tagged Fish from Aircraft. N. American J. Fisheries Management 17:457-460.

Section 10. Information/technology transfer

We propose that NMFS continue its activities of interfacing with other agencies (e.g., PSMFC, COE, BPA, and Tribal Nations) regarding PIT-tag technology (e.g., facility design to accommodate PIT-tag systems, system maintenance, system design specifications, assistance in using prototype equipment and MULTIMON program, information transfer). Since NMFS personnel designed or helped develop many of the present PIT-tag system's components within the CRB, they are an important resource for providing technical support and training to ensure the reliable operation of PIT-tag systems throughout the Basin.

Technical reports, scientific papers, meetings, and workshops are important means of transferring information and technology. During the performance period, NMFS proposes to complete a report describing the results of PIT-tag development and evaluation work and to participate in meetings and workshops.

Congratulations!